

# Computer Display Industry and Technology Profile

## 1.0 Introduction

Since World War II, cathode ray tube (CRT) electronic displays have played an increasingly important role in our lives, with televisions and personal computers being the primary applications. In the 1970's, the liquid crystal display (LCD) became popular in wristwatches and calculators. In the early 1980s, Epson introduced the first portable computer with a monochrome LCD display, followed soon by LCD monitor displays from Tandy and Toshiba. These electronic displays are commonly referred to as flat panel displays (FPDs).

There are now a number of flat panel displays (FPDs), each providing particular advantages for a given application. Appendix A<sup>1</sup> provides an overview of LCD and other FPD technologies. The LCD is by far the most common type of FPD, and currently is the only FPD used in commercial computer monitors, which includes laptop monitors. Computer monitors constituted approximately 54.7 percent of the \$13.9 billion LCD market in 1997, and are predicted to increase to 67.4 percent of the \$31.5 billion market in 2001.<sup>2</sup> LCDs comprised 87.6 percent of all FPD applications in 1997, and are expected to drop only slightly to 85.8 percent in 2003.<sup>3</sup> LCDs have greatly increased in number, type, and applications, including growth in the desktop monitor application. LCD desktop monitors, although not yet numerous in the commercial sector, appear to be a likely replacement technology for CRTs. Therefore, the potential for high market penetration and an increased LCD material volume is significant.

Concern over the environmental impact associated with the manufacture, use, and disposition of electronic products has emerged in recent years. These concerns have been driven in part because computer manufacturing requires the use of some toxic materials that may pose occupational and environmental risks. Concern has also been raised by the

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<sup>1</sup> Socolof, M.L., et al., *Environmental Life-Cycle Assessment of Desktop Computer Displays: Goal Definition and Scoping*, (Draft Final), University of Tennessee Center for Clean Products and Clean Technologies, July 24, 1998.

<sup>2</sup> Stanford Resources, presentation at the 1998 United States Display Consortium (USDC) Business Conference, San Jose, CA.

<sup>3</sup> Ibid.

growing numbers of consumer electronic products in the marketplace, creating an increasing volume of end-of-life (EOL) materials and some calls for changes in EOL management, especially in Europe. Producers, customers, legislators, regulators, and municipalities are interested in examining the resources used to produce and use these products, and in reducing environmental impacts throughout the entire computer product life cycle, especially during disposition at EOL.

In the consumer realm, CRT displays in televisions and computers dominate in terms of material volume, while LCDs found in household equipment (e.g., microwaves, stereos) and consumer items (e.g., watches, cell phones, pagers) dominate in terms of number of displays. Looking at all electronic displays in terms of material volume, it is helpful to analyze three categories separately. The largest displays (>40-inches) are generally in projection format, and thus consume relatively small material volumes; they are also produced in relatively small unit volumes. The smallest displays (<5-inches) are produced in large volumes (over 1.6 billion units in 1998), but tend to be part of larger systems (appliances, stereos) and so are a relatively small part of the overall material volume. It is in the middle sizes (5- to 40-inches) that the display material volume is a large fraction of the system, and unit volumes are significant.

In order to assess environmental impacts of both CRTs and LCDs during manufacturing, use, and disposition stages, the United States Environmental Protection Agency Design for the Environment (DfE) Program formed a voluntary partnership with the display industry. The goal of the DfE Computer Display Project is to study the life cycle environmental impacts of CRT and LCD desktop computer displays, and generate data that will assist the display industry to make environmentally informed decisions and identify areas for improvement. The selection of these two types of displays was based on potential end-of-life material volume, widespread use, and the ability to compare two display types with the same functional unit—desktop computer application.

The purpose of the Computer Display Industry and Technology Profile is to provide an overview of the CRT and LCD computer monitor markets and technologies. Section 2.0 presents a market profile based on currently available data. The profile is not an exhaustive market assessment, and does not intend to imply preference to one technology type. Section 3.0, Technology Profile, presents an explanation of the basic operation and manufacturing of CRTs and thin-film transistor (TFT) -LCDs to readers relatively unfamiliar with the topic.